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GEOELECTRIC PARAMETERS AND ELEMENTAL COMPOSITIONS OF THE TOP SOIL OF CAMP AREA, ABEOKUTA, SOUTH WESTERN NIGERIA

[1]*V. MAKINDE, [1]I.C OKEYODE, [2]J.O. COKER, [1]F.G. AKINBORO, [1]J.O. AINA, AND [1]S.A. ISHOLA

[1.]Department of Physics, Federal University of Agriculture, Abeokuta
[2.]Department of Physics, Lagos State Polytechnic, Ikorodu, Lagos

***Corresponding author:** victor_makindeii@yahoo.com **Tel:** +2348035994001

ABSTRACT

Vertical Electrical Sounding (VES) and elemental composition surveys were carried out at twenty-two (22) sites at Camp Area, Alabata Road, Abeokuta, Southwestern Nigeria. This was with a view to determining depth to water–bearing zones and extent of soil contamination thereby saving residents not just the pain of recurrent losses incurred for investing in dry wells, but also not to invest in contaminated waters. The study area is underlain by associated rock suites which includes pegmatite and quartz veins. Field data obtained was modeled and interpreted to obtain the geophysical parameters of the area and delineate the groundwater potential zones. Soil samples were also collected at the 22 VES points, at depths of 10 cm and 100 cm; the Global Positioning Satellite (GPS) equipment was used to obtain the geographical position of each sample point. Determination of the elemental composition of soil samples collected at the 10 cm and 100 cm depths was made using Atomic Absorption Spectrophotometer. Two heavy metals (Pb, and Cr), five major elements (K, Ca, N, P and Mg) and five trace elements (Zn, Mn, Cu, Al and Fe) were detected. It was observed that the values, representing the amount of the heavy metals, the major elements, and the trace elements were far less, mostly insignificant, at the 100 cm depth representing about the interface between the first and second layers in majority of the VES stations sampled, than at the 10 cm depth, representing the topsoil of the first layer. The implication of this is that the elements are not strictly domiciled within the area studied but may be due to runoffs as the area slopes down. Moreover, going by the values at the 100 cm depth, the elements may not be capable of percolating into the underground water zones in the area of study, and thus might not have contaminated the underground water. Thus, at the current level, the underground water can be adjudged safe for human consumption.

Key words: Vertical Electrical Sounding (VES), geophysical parameters, water-bearing zones, elemental composition, top soil

INTRODUCTION

soils, including agThe concentrations of trace and major elements depend on the geology of the local environment as well as other natural and anthropogenic processes. Major elements (ME) and trace elements (TE) in virgin soil are generally dependent on the lithology of soil parent material and, the geochemical and pedological processes responsible for the formation of soils (Hardy and Cornu, 2006; Mitchell, 1960). However, many human activities in-

crease TE in ricultural practices, such as phosphate fertilizers, pesticides, waste water effluents, and biosolid application. Soil is considered contaminated when chemicals are present or other alterations have been made to its natural environment (Gowd et al., 2010). The elemental composition of soil type affects the nutrients derived from plants by man after consumption. This varies over soil texture, types and depth (Marshall and Holmes, 1979; Oyeyemi et al., 2011). Some elements such as mercury (Hg), Cadmium (Cd), Arsenic (As), Chromium (Cr) Thallium (Tl) and lead have relative high density; they are heavy metals and are toxic or poisonous at low concentration. (Oyeyemi et at., 2011).

Due to the fact that environmental problems, such as pollution, acidification, erosion, desertification, and climatic change, among others, are increasingly becoming matter of public concern, an understanding of soils within an environment is also becoming increasingly important (White, 1979, Okeyode and Moshood, 2010).

In this work, geophysical investigation coupled with elemental assessment of soil in the area was undertaken to verify whether or not the groundwater has been contaminated through water percolation and leaching, which could over the years, have driven heavy metals and contaminants into the groundwater supply of the area through the fractured and weathered zones.

GEOLOGY OF THE STUDY AREA

The study area lies within the southwestern part of the Nigerian Precambrian basement complex. The dominant rock types in the locality of which the study area is a part are quartzite, banded gneiss and granite gneiss. Associated rock suites found in all the major outcrops in the study area include pegmatite and quartz veins.

Quartzite outcrops occur as ridges with relatively high elevation and are commonly Schistose in form. Their strike line runs in the north-south direction, dipping eastwards with characteristic cross cutting features. The dominant minerals are quartz (80%), muscovite (19%), iron oxide (0.9%) and biotite (0.1%).

According to Rahaman (1989), the basement complex of Southwestern Nigeria lies to the east of the West African Craton in the region of late Precambrian to early Palaezoic orogenesis. The Basement Complex rocks of Nigeria are composed predominantly of migmatitic and granitic gneisses; quartzites; slightly dioritic rocks and the members of the Older Granite suite mainly granites, granodiorites and syenties. The early gneisses are best seen in the migmatites as dyke-like bodies scattered over a wide area; the charnockites occur in three main areas – around Iwo, Ara, Awo, Osuntedo, and Wasinmi; with outcrops in Odeda and Abeokuta. Generally, wells from quartzite underlain areas produce more water than wells from other rock types, which according to Olorunfemi and Okhue (1992), is because their transmissivity and permeability are higher as a result of the large presence of fissures and quartz veins; the sought after groundwater is contained in weathered and fractured/jointed basement. The localization of groundwater in fractured and weathered zone will, according to Palacky et al. (1981), make the yield of wells in crystalline bedrock terrain to be highly variable.

Abeokuta is located in the south western part of Nigeria; it lies approximately on latitude $7^{0}3'$N and longitude $3^{0}5'$E. The average

annual minimum temperature of Abeokuta is about 22^0C, while the average maximum temperature is in the neighborhood of about 30^0C. The area investigated has a land mass of about 3.75 square kilometres. The soil of the area belongs to the remnant of the complex basement rock of coastal area, and is thus ferralitic. Most of the soils are sand-loamy compacted with intercalated clays.

METHOD OF INVESTIGATION AND DATA ANALYSIS

In investigating the geoelectrical parameters and elemental compositions of the soil of Camp Area, the Schlumberger array of the electrical resistivity method was used for the geoelectrical investigation, while the elemental analysis was carried out using the Atomic Absorption Spectrophotometer. The Global Positioning Satellite (GPS) equipment was used to obtain the geographical position of each sampled point. Samples were collected at depths of 10 cm and 100 cm from the sites of each of the twenty-two (22) VES locations investigated at Camp Area, Alabata Road, Abeokuta, Ogun State, Nigeria. The process of investigation is next further highlighted.

Geophysical investigation

The electrical resistivity method has been applied most widely in groundwater exploration studies (Todd, 1980); this is because it can clarify the subsurface structure, delineate groundwater zone and is inexpensive (Mazae et al, 1985). The electrical resistivity method can be best employed to estimate the thickness of overburden and also the thickness of weathered/fractured zones with reasonable accuracy (Zohdy et al., 1974).

Figure 1, which is the location and data acquisition map of the study area, shows the 22 sounding points. The four electrode Schlumberger array with a maximum current electrode spacing, AB of 200m, was used for this survey. An ABEM® 300 Terrameter was used to measure and record the resistance of the subsurface. For each electrode configuration for which a sounding was made, a reading of resistance R of the volume of earth material within the space of the electrodes was obtained and a configuration factor K was calculated using equation (2). The product of K and R was then made to obtain the apparent resistivity of the earth material beneath the investigated surface. This was subsequently done on all the point data obtained for each VES station to give the set of apparent resistivity values supplied for computer modeling using WinGLink program for the iteration to obtain the geoelectrical parameters.

$$R = \frac{V}{I} \qquad \ldots\ldots\ldots (1)$$

$$K = \pi\left[\frac{AB^2}{MN} - \frac{MN}{4}\right] \qquad \ldots\ldots(2)$$

$$\rho_a = KR \qquad \ldots\ldots\ldots(3)$$

Soil investigation: soil sample collection and sample preparation

Soil samples were collected at the 22 VES locations as shown in the map of the investigated area (Fig.1). The geographical location of each sample point was taken by means of a GPS. Each soil sample was packed separately in a polythene bag, sealed, and labeled to avoid the mixing up of samples or contaminations. The samples were dried, ground and sieved.

Elemental analysis was carried out using the Atomic Absorption Spectrophotometer (AAS). The wavelength of the elements of interest ranged from 213.8 nm to 766.5 nm. 2g of each sample was digested by adding a tablet of selenium and 10 ml each of concentrated nitric and perchloric acids in a digestion tube and centrifuged at 3000 rpm for 30 minutes. The supernatant was measured for its absorbance and compared with a standardized AAS.

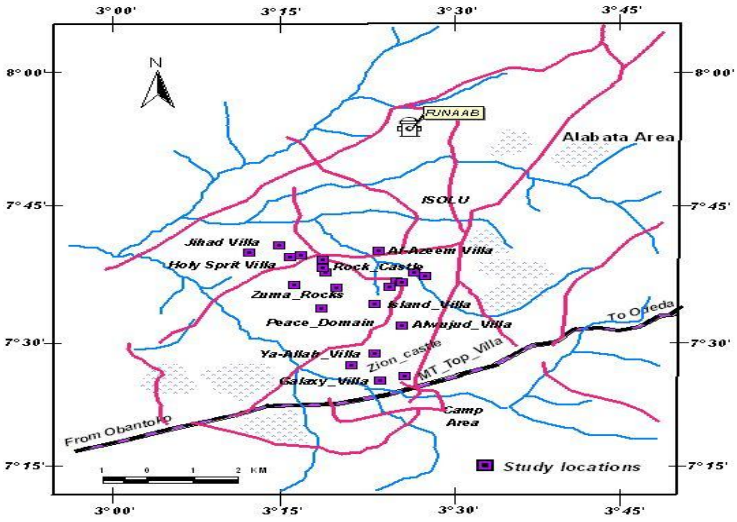

Fig 1: Map showing the Study Area

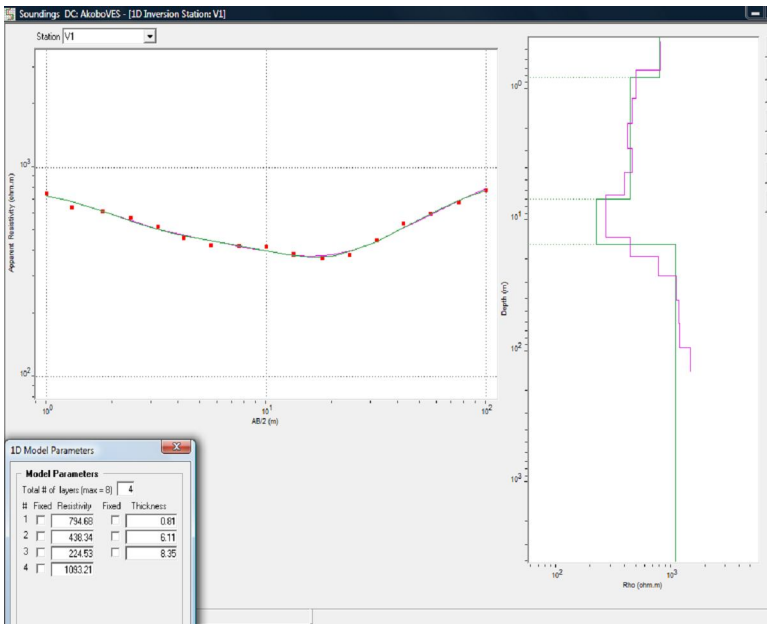

Fig. 2: Typical VES Plot

RESULTS AND DISCUSSION

Table 1: shows the typical VES results of the first (top), and second layers of the

Table 1: Summary of VES Results for the first two layers at the Study Sites

VES Station	Layer	Resistivity (ohm-m)	Thickness (m)	Overburden Thickness (m)	Lithology
1	1	2186.45	0.38	0.38	Topsoil
	2	42.87	5.98	6.36	Shale/Clay
2	1	1488.86	0.43	0.43	Topsoil
	2	388.05	3.27	3.70	Clayey sand
3	1	185.09	1.74	1.74	Topsoil
	2	861.60	3.46	5.20	Clayey sand
4	1	290.44	0.49	0.49	Topsoil
	2	468.26	5.18	5.67	Clayey sand
5	1	701.83	0.67	0.67	Topsoil
	2	165.81	5.56	6.23	Sandy clay
6	1	261.01	0.92	0.92	Topsoil
	2	168.25	11.83	12.75	Sandy clay
7	1	4209.29	0.15	0.15	Topsoil
	2	120.54	9.61	9.76	Sandy clay
8	1	42.38	1.04	1.04	Topsoil
	2	24.61	13.11	14.15	Shale/Clay
9	1	794.68	0.81	0.81	Topsoil
	2	438.34	6.11	6.92	Clayey sand
10	1	2713.13	0.80	0.80	Topsoil
	2	239.32	7.86	8.66	Sandy clay
11	1	1859.64	0.29	0.29	Topsoil
	2	232.35	2.84	3.13	Sandy clay
12	1	355.75	0.82	0.82	Topsoil
	2	189.01	5.12	5.94	Sandy clay
13	1	224.55	0.89	0.89	Topsoil
	2	26.18	12.31	13.20	Shale/Clay
14	1	395.59	0.71	0.71	Topsoil
	2	25.34	5.09	5.80	Shale/Clay
15	1	1015.82	0.31	0.31	Topsoil
	2	186.20	1.99	2.30	Sandy clay
16	1	634.71	3.18	3.18	Topsoil
	2	53.45	8.12	11.30	Shale/Clay
17	1	236.64	9.78	9.78	Topsoil
	2	85.53	17.06	26.84	Shale/Clay
18	1	184.84	1.77	1.77	Topsoil
	2	383.70	1.76	3.53	Clayey sand
19	1	1697.76	0.33	0.33	Topsoil
	2	171.79	3.28	3.61	Sandy clay
20	1	200.58	1.05	1.05	Topsoil
	2	80.36	16.52	17.57	Shale/Clay
21	1	805.48	0.27	0.27	Topsoil
	2	183.45	6.41	6.68	Sandy clay
22	1	182..05	1.72	1.72	Topsoil
	2	861.60	3.45	5.17	Clayey sand

Subsurface as obtained from the interpreted data. From the general interpretation of the VES data obtained, the area is predominantly three-layered; with the H-type being the only type of three–layer VES sounding curve obtained in this area. However, there also existed pockets of a number of four–layered type of VES curves namely QH, HA and KH, meaning that in this area the types of curves obtained are H-type, HA–type, QH–type and KH-type. Typical VES plot obtained in the area are as shown in fig. 2. In basemelayer of H-type is commonly water saturated and is often characterized by low resistivity, high porosity, low specific yield and low permeability (Jones, 1985). However, only the uppermost layers within 100 cm (1 m) to the surface are relevant to this work as that is the region of exchange of ions from heavy metals and contaminants, and from where the contaminants are conveyed into the underground water zones through processes already highlighted. The depth of 1m, in most cases as seen from the interpreted VES data, encloses the top layer, the boundary between the first and second layer, and a sizeable depth into the second layer. The essence of sampling this depth was to determine whether or not the contaminants have been able to migrate beyond the first layer into the targeted groundwater zones in the subsurface.

Table 2 shows the elemental concentration (in ppm) of the samples at the 10 cm depth, while table 3 shows the elemental concentration (in ppm) of the samples at the 100 cm depth. It was noted that the concentration values of all the elements decreased down the depth. The higher values were obtained at the 10 cm depths and lower values of each of the elements were obtained at 100cm depths. From the descriptive analysis (Tables 4 and 5). Phosporus (P) had the highest overall average value of 78.35 ppm ranging from 22.65 – 114.96 ppm. In the group of heavy metals, lead (Pb) had the highest overall average value of (33.78 ppm) ranging from 1.45 – 49.68 ppm. The highest value was obtained at VES location 9. The high value of lead content found at this location could be traced to the unsorted solid waste dumpsite not too far from the locality. The pollution of soil by lead and other heavy minerals is a very serious problem due to the fact that lead is a cumulative pollutant (Dara, 1993) and the continuous disposal of lead containing waste into the environment is generally hazardous. Considering the correlation analysis of the elemental concentrations at the depths with the resistivity values obtained, it was noted that Cr correlated positively well with K (0.94), Ca (0.82), and Al (0.73); and averagely with Mn (0.59), Mg (0.69), and Fe (0.57). Pb correlated averagely with K (0.63) and, weakly with N(0.52), Ca (0.43), and Cr (0.45).

None of the elements correlated with the resistivity values at the locations studied.
The frequency distribution curves for the heavy metals at the studied depths are also shown in figures 3 and 4 respectively. It was observed that the distribution for chromium Cr, was almost the same at both depths; but for Pb, at the 10 cm depth, the distribution was skewed to the higher values and was normally distributed at the 100 cm depth, implying a thinning down effect at this depth. Table 6 shows the elemental values obtained at the 1 m sampling depth while table 7 shows the concentration of the elements at the 100 cm depth.

Table 2: Elemental concentration (ppm) of the samples at 10 cm

Sample	P	N	K	Zn	Mn	Mg	Ca	Pb	Fe	Cu	Cr	Al
VES 1	112.07	0.18	0.74	0.85	8.40	19.00	3.85	33.80	25.50	28.50	22.35	6.20
VES 2	54.76	0.13	1.17	0.60	5.60	34.00	7.50	39.45	23.50	21.90	29.90	5.50
VES 3	70.12	0.24	1.11	5.60	8.50	29.65	6.10	29.20	23.50	29.00	33.15	5.50
VES 4	113.08	0.17	0.76	0.85	8.40	19.00	3.85	33.90	25.50	28.60	22.35	6.20
VES 5	114.05	0.17	0.74	0.85	8.40	19.22	3.85	33.80	25.50	28.50	22.35	6.20
VES 6	65.25	0.13	0.75	0.70	15.70	20.50	4.28	26.20	37.55	19.90	19.65	6.60
VES 7	65.59	0.31	0.73	5.60	8.60	18.85	3.83	8.55	30.50	19.50	21.45	6.55
VES 8	65.25	0.13	0.75	0.70	15.70	20.50	4.28	26.20	37.50	19.90	19.65	6.60
VES 9	54.47	0.12	1.11	1.90	10.70	28.50	5.75	49.60	30.00	25.50	30.10	6.35
VES 10	113.05	0.17	0.71	0.85	8.45	18.96	3.85	33.80	25.50	28.50	22.40	6.25
VES 11	114.96	0.18	1.18	0.80	8.75	29.15	5.93	30.95	28.15	23.50	30.90	5.20
VES 12	54.47	0.12	1.11	1.90	10.70	28.50	5.75	48.25	30.00	25.50	30.10	6.35
VES 13	65.25	0.13	0.75	0.70	15.70	20.50	4.28	26.20	37.55	19.90	19.65	6.60
VES 14	57.47	0.12	1.11	1.90	10.70	28.50	5.75	49.15	30.00	25.50	30.10	6.35
VES 15	65.47	0.13	0.75	0.70	15.70	20.50	4.28	26.20	37.55	19.90	19.65	6.60
VES 16	54.76	0.13	1.17	0.60	5.60	34.00	7.50	39.45	23.50	21.90	29.90	5.50
VES 17	76.32	0.32	1.03	5.65	8.40	28.00	5.68	26.35	28.65	20.50	31.15	6.20
VES 18	114.22	0.18	1.18	0.80	8.75	29.15	5.93	30.95	28.15	23.50	30.90	5.20
VES 19	54.47	0.12	1.11	1.90	10.70	28.50	5.75	47.85	30.00	25.50	30.10	6.35
VES 20	70.12	0.24	1.11	5.60	8.50	29.65	6.10	29.20	23.50	29.00	33.15	5.50
VES 21	113.73	0.18	1.18	0.80	8.75	29.15	5.93	30.95	28.15	23.50	30.90	5.20
VES 22	54.76	0.13	1.17	0.60	5.60	34.00	7.50	39.45	23.50	21.90	29.90	5.50

Table 3: Elemental concentration (ppm) of the samples at 100 cm

Sample	P	N	K	Zn	Mn	Mg	Ca	Pb	Fe	Cu	Cr	Al
VES 1	81.55	0.16	0.71	0.82	8.40	17.00	3.25	21.50	24.50	27.50	22.25	6.20
VES 2	22.65	0.12	1.13	0.60	5.60	31.00	7.30	27.25	22.50	21.20	29.70	5.50
VES 3	49.08	0.23	1.04	5.60	8.50	27.55	6.00	16.80	22.50	29.00	33.05	5.50
VES 4	83.10	0.15	0.72	0.83	8.40	16.50	3.55	21.65	23.50	28.30	22.25	6.20
VES 5	82.05	0.14	0.71	0.84	8.40	17.00	3.50	21.75	23.50	27.80	22.35	6.20
VES 6	34.25	0.12	0.72	0.70	15.65	19.50	4.05	13.25	35.85	18.60	19.60	6.60
VES 7	35.38	0.30	0.72	5.55	8.60	17.65	3.50	1.45	30.00	18.50	21.40	6.50
VES 8	34.65	0.11	0.73	0.70	15.70	18.50	4.05	16.25	36.50	18.60	19.55	6.60
VES 9	24.22	0.11	1.10	1.89	10.70	18.50	5.45	36.55	30.00	24.75	30.00	6.35
VES 10	82.65	0.15	0.68	0.84	8.45	18.75	3.65	22.60	24.50	27.50	22.35	6.25
VES 11	84.72	0.16	1.15	0.80	8.75	17.10	5.70	20.45	26.15	22.50	30.80	5.20
VES 12	23.25	0.11	1.09	1.89	10.70	17.50	5.70	35.50	29.50	24.70	30.00	6.35
VES 13	34.20	0.12	0.72	0.70	15.70	18.50	4.15	15.10	36.65	18.50	19.60	6.60
VES 14	26.62	0.10	1.09	1.90	10.70	26.50	5.75	36.45	30.00	24.50	30.00	6.35
VES 15	34.55	0.11	0.74	0.70	15.70	18.50	4.15	15.10	35.85	18.50	19.60	6.60
VES 16	54.46	0.11	1.15	0.60	5.60	33.00	7.50	26.55	22.50	20.50	29.80	5.50
VES 17	45.05	0.31	1.01	5.63	8.40	26.00	5.55	14.45	26.65	19.75	31.10	6.20
VES 18	84.20	0.16	1.15	0.79	8.75	26.10	5.90	20.55	27.15	22.50	30.85	5.20
VES 19	23.39	0.11	1.10	1.90	10.70	26.50	5.55	36.15	29.50	23.85	30.05	6.25
VES 20	40.84	0.22	1.10	5.59	8.50	26.50	6.10	17.25	21.50	28.00	33.10	5.50
VES 21	83.06	0.16	1.16	0.78	8.70	26.10	5.85	18.75	26.85	22.50	30.80	5.20
VES 22	23.28	0.12	1.16	0.60	5.60	31.00	7.45	26.35	22.50	21.20	29.80	5.50

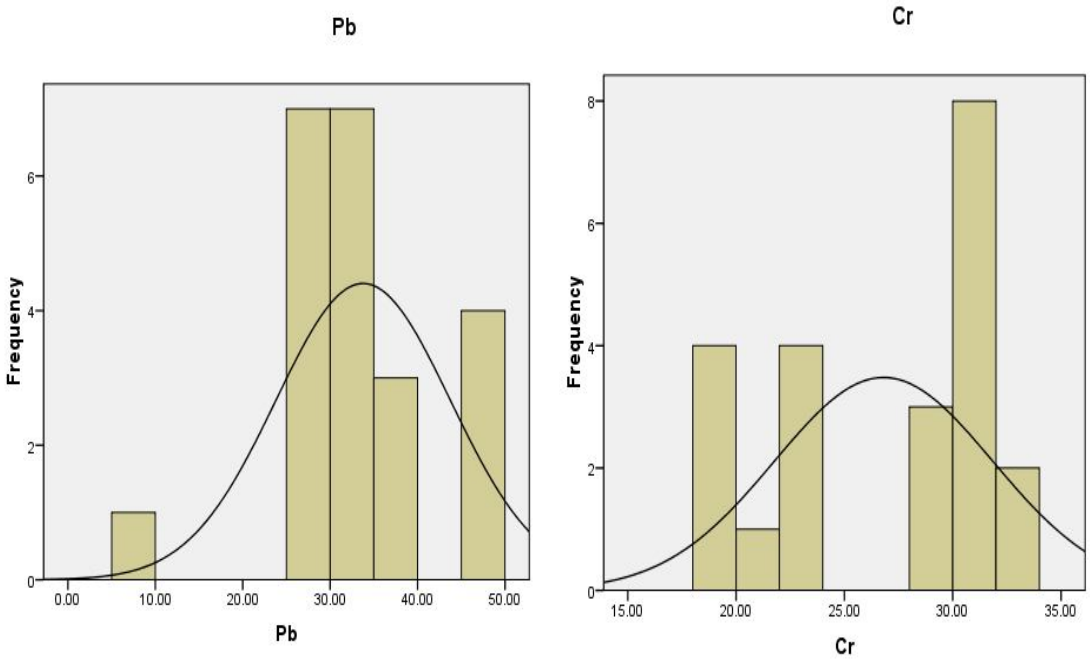

Fig. 3: Frequency distribution of the heavy metals at the 10 cm depth

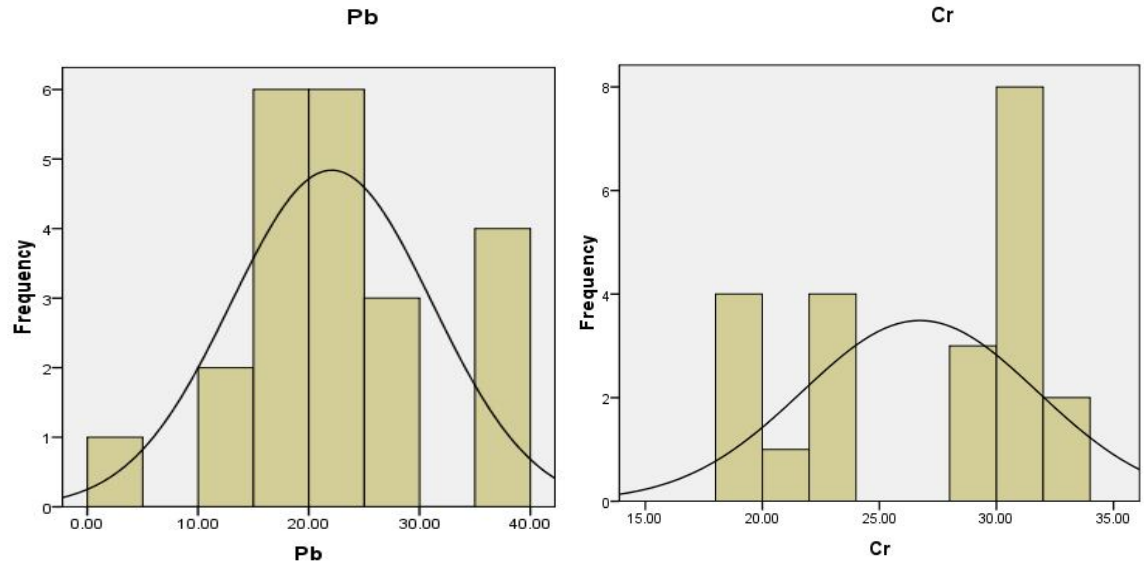

Fig. 4: Frequency distribution of the heavy metals at the 100 cm depth

Table 6: Correlation Analysis of the Elemental Parameters with Resistivity at 10cm

		P	N	K	Zn	Mn	Mg	Ca	Pb	Fe	Cu	Cr	Al	Resistivity
P	Pearson Correlation	1	0.245	-0.231	-0.23	-0.21	-0.377	-0.41	-0.26	-0.25	0.421	-0.14	-0.31	0.177
	Sig. (2-tailed)		0.272	0.301	0.312	0.34	0.084	0.06	0.251	0.258	0.051	0.54	0.166	0.432
	N	22	22	22	22	22	22	22	22	22	22	22	22	22
N	Pearson Correlation	0.245	1	-0.071	.816**	-0.31	-0.109	-0.14	-.647**	-0.26	0.043	0.16	-0.14	0.305
	Sig. (2-tailed)	0.272		0.752	0	0.16	0.63	0.52	0.001	0.241	0.851	0.49	0.53	0.168
	N	22	22	22	22	22	22	22	22	22	22	22	22	22
K	Pearson Correlation	-0.23	-0.07	1	0.119	-.503*	.962**	.918**	.512*	-.460*	0.064	.944**	-.735**	-0.29
	Sig. (2-tailed)	0.301	0.752		0.598	0.02	0	0	0.015	0.031	0.779	0	0	0.19
	N	22	22	22	22	22	22	22	22	22	22	22	22	22
Zn	Pearson Correlation	-0.23	.816**	0.119	1	-0.18	0.1	0.05	-0.34	-0.2	0.13	0.36	-0	0.121
	Sig. (2-tailed)	0.312	0	0.598		0.44	0.658	0.84	0.127	0.368	0.564	0.1	0.988	0.591
	N	22	22	22	22	22	22	22	22	22	22	22	22	22
Mn	Pearson Correlation	-0.21	-0.31	-.503*	-0.18	1	-.531*	-.539**	-0.2	.949**	-0.39	-.594**	.677**	-0.219
	Sig. (2-tailed)	0.343	0.161	0.017	0.437		0.011	0.01	0.377	0	0.072	0	0.001	0.327
	N	22	22	22	22	22	22	22	22	22	22	22	22	22
Mg	Pearson Correlation	-0.38	-0.11	.962**	0.1	-.531*	1	.990**	.488*	-.482*	-0.03	.888**	-.704**	-0.317
	Sig. (2-tailed)	0.084	0.63	0	0.658	0.01		0	0.021	0.023	0.88	0	0	0.151
	N	22	22	22	22	22	22	22	22	22	22	22	22	22
Ca	Pearson Correlation	-0.41	-0.14	.918**	0.047	-.539**	.990**	1	.453*	-.482*	-0.09	.823**	-.696**	-0.309
	Sig. (2-tailed)	0.058	0.523	0	0.837	0.01	0		0.034	0.023	0.683	0	0	0.162
	N	22	22	22	22	22	22	22	22	22	22	22	22	22

Table 6: Correlation Analysis of the Elemental Parameters with Resistivity at 10cm

Pb	Pearson Correlation	-0.26	-.647**	.512*	-0.34	-0.2	.488*	.453*	1	-0.26	0.388	.462*	-0.08	-0.297
	Sig. (2-tailed)	0.251	0.001	0.015	0.127	0.38	0.021	0.03		0.239	0.075	0.03	0.728	0.18
	N	22	22	22	22	22	22	22	22	22	22	22	22	22
Fe	Pearson Correlation	-0.25	-0.26	-.460*	-0.2	.949**	-.482*	-.482*	-0.26	1	-.622**	-.600**	.672**	-0.1
	Sig. (2-tailed)	0.258	0.241	0.031	0.368	0	0.023	0.02	0.239		0.002	0	0.001	0.657
	N	22	22	22	22	22	22	22	22	22	22	22	22	22
Cu	Pearson Correlation	0.421	0.043	0.064	0.13	-0.39	-0.034	-0.09	0.388	-.622**	1	0.28	-0.21	-0.011
	Sig. (2-tailed)	0.051	0.851	0.779	0.564	0.07	0.88	0.68	0.075	0.002		0.21	0.359	0.962
	N	22	22	22	22	22	22	22	22	22	22	22	22	22
Cr	Pearson Correlation	-0.14	0.157	.944**	0.357	-.594**	.888**	.823**	.462*	-.600**	0.28	1	-.716**	-0.242
	Sig. (2-tailed)	0.54	0.486	0	0.103	0	0	0	0.031	0.003	0.206		0	0.278
	N	22	22	22	22	22	22	22	22	22	22	22	22	22
Al	Pearson Correlation	-0.31	-0.14	-.735**	-0	.677**	-.704**	-.696**	-0.08	.672**	-0.21	-.716**	1	0.145
	Sig. (2-tailed)	0.166	0.53	0	0.988	0	0	0	0.728	0.001	0.359	0		0.52
	N	22	22	22	22	22	22	22	22	22	22	22	22	22
Resistivity	Pearson Correlation	0.177	0.305	-0.29	0.121	-0.22	-0.317	-0.31	-0.3	-0.1	-0.01	-0.24	0.145	1
	Sig. (2-tailed)	0.432	0.168	0.19	0.591	0.33	0.151	0.16	0.18	0.657	0.962	0.28	0.52	
	N	22	22	22	22	22	22	22	22	22	22	22	22	22

*. Correlation is significant at the 0.05 level (2-tailed).

**. Correlation is significant at the 0.01 level (2-tailed).

Table 7: Correlation Analysis of the Elemental Parameters with Resistivity at 100cm

		Cr	Pb	P	N	K	Zn	Mn	Mg	Ca	Fe	Cu	Al	Resistivity
Cr	Pearson Correlation	1	.452*	-0.078	0.176	.936**	0.361	-.593**	.668**	.821**	-.570**	0.3	-.723**	0.343
	Sig. (2-tailed)		0.035	0.731	0.434	0	0.099	0	0	0	0.006	0.18	0	0.118
	N	22	22	22	22	22	22	22	22	22	22	22	22	22
Pb	Pearson Correlation	.452*	1	-0.249	-.629**	.515*	-0.329	-0.19	0.23	.425*	-0.17	0.35	-0.07	0.116
	Sig. (2-tailed)	0.035		0.264	0.002	0.01	0.135	0.39	0.3	0.049	0.439	0.11	0.774	0.608
	N	22	22	22	22	22	22	22	22	22	22	22	22	22
P	Pearson Correlation	-0.08	-0.25	1	0.17	-0.19	-0.226	-0.3	-0.26	-0.32	-0.4	0.42	-0.38	-0.036
	Sig. (2-tailed)	0.731	0.264		0.451	0.4	0.312	0.17	0.24	0.145	0.069	0.05	0.078	0.872
	N	22	22	22	22	22	22	22	22	22	22	22	22	22
N	Pearson Correlation	0.176	-.629**	0.17	1	-0.06	.837**	-0.3	0.02	-0.12	-0.27	0.04	-0.13	0.021
	Sig. (2-tailed)	0.434	0.002	0.451		0.8	0	0.18	0.93	0.612	0.218	0.86	0.569	0.926
	N	22	22	22	22	22	22	22	22	22	22	22	22	22
K	Pearson Correlation	.936**	.515*	-0.19	-0.06	1	0.118	-.491*	.710**	.916**	-0.4	0.05	-.721**	0.301
	Sig. (2-tailed)	0	0.014	0.398	0.802		0.6	0.02	0	0	0.064	0.83	0	0.173
	N	22	22	22	22	22	22	22	22	22	22	22	22	22
Zn	Pearson Correlation	0.361	-0.33	-0.226	.837**	0.12	1	-0.17	0.15	0.061	-0.2	0.16	-0.01	0.061
	Sig. (2-tailed)	0.099	0.135	0.312	0	0.6		0.44	0.52	0.787	0.37	0.48	0.951	0.788
	N	22	22	22	22	22	22	22	22	22	22	22	22	22
Mn	Pearson Correlation	-.593**	-0.19	-0.301	-0.3	-.491*	-0.173	1	-.517*	-.507*	.935**	-0.42	.684**	-0.381
	Sig. (2-tailed)	0.004	0.393	0.174	0.179	0.02	0.442		0.01	0.016	0	0.05	0	0.08
	N	22	22	22	22	22	22	22	22	22	22	22	22	22

Table 7: Correlation Analysis of the Elemental Parameters with Resistivity at 100cm

Mg	Pearson Correlation	.668**	0.233	-0.261	0.019	.710**	0.145	-.517*	1	.862**	-.451*	-0.09	-.604**	0.294
	Sig. (2-tailed)	0.001	0.297	0.242	0.932	0	0.519	0.01		0	0.035	0.71	0.003	0.185
	N	22	22	22	22	22	22	22	22	22	22	22	22	22
Ca	Pearson Correlation	.821**	.425*	-0.321	-0.12	.916**	0.061	-.507*	.862**	1	-0.42	-0.09	-.691**	0.367
	Sig. (2-tailed)	0	0.049	0.145	0.612	0	0.787	0.02	0		0.05	0.69	0	0.093
	N	22	22	22	22	22	22	22	22	22	22	22	22	22
Fe	Pearson Correlation	-.570**	-0.17	-0.395	-0.27	-0.4	-0.201	.935**	-.451*	-0.42	1	-.641**	.688**	-0.419
	Sig. (2-tailed)	0.006	0.439	0.069	0.218	0.06	0.37	0	0.04	0.05		0	0	0.052
	N	22	22	22	22	22	22	22	22	22	22	22	22	22
Cu	Pearson Correlation	0.299	0.353	0.423	0.041	0.05	0.158	-0.42	-0.09	-0.09	-.641**	1	-0.22	0.287
	Sig. (2-tailed)	0.176	0.107	0.05	0.855	0.83	0.483	0.05	0.71	0.692	0.001		0.315	0.196
	N	22	22	22	22	22	22	22	22	22	22	22	22	22
Al	Pearson Correlation	-.723**	-0.07	-0.384	-0.13	-.721**	-0.014	.684**	-.604**	-.691**	.688**	-0.22	1	-0.412
	Sig. (2-tailed)	0	0.774	0.078	0.569	0	0.951	0	0	0	0	0.32		0.057
	N	22	22	22	22	22	22	22	22	22	22	22	22	22
Resistivity	Pearson Correlation	0.343	0.116	-0.036	0.021	0.3	0.061	-0.38	0.29	0.367	-0.42	0.29	-0.41	1
	Sig. (2-tailed)	0.118	0.608	0.872	0.926	0.17	0.788	0.08	0.19	0.093	0.052	0.2	0.057	
	N	22	22	22	22	22	22	22	22	22	22	22	22	22

*. Correlation is significant at the 0.05 level (2-tailed).
**. Correlation is significant at the 0.01 level (2-tailed).

Zinc, Copper, Iron and Aluminium while Chromium and Lead are the heavy metals detected at the study areas. The concentration values decreased down the depth.The implication of this is that the elements have not strictly domiciled within the area studied but may be due to runoffs as the area slopes down. Moreover, going by the values at the 100 cm depth, the elements may not be capable of percolating into the underground water zones in the area of study, and thus might not have contaminated the underground water. Thus, at the current level of overburden contamination, the underground water can be said to be safe for human consumption.

It can therefore be concluded that in most cases, the average thickness of the topmost layer in the Camp Area does not exceed 1m. The elemental values obtained at the 1 m sampling depth (table 6) is much lower than that obtained at the 10 cm sampling depth, which in itself is not high enough to cause contamination. The overall implication is therefore that in this area, the concentration of the elements is too low at the 100 cm depth (table 7) to find its way into the underground water zones and contaminate the underground water supply, and hence become hazardous to the local populace. The elemental composition values obtained for the soil in Camp Area, Alabata Road, Abeokuta could be used as a baseline value to evaluate the extent of any pollution in the soil in the future.

CONCLUSION

Vertical Electrical Sounding (VES) activity as well as soil analyses for heavy metals and contaminants have been carried out in twenty-two (22) stations in the Camp Area, Alabata Road, Abeokuta, Southwestern Nigeria. Weathered and fractured horizons constituting the aquifer zones have been identified in the area underlying the VES stations. Good prospects therefore exist for groundwater development in the study area where the depth to basement is relatively thick and has low resistivity values. Based on the interpreted results of the electrical resistivity survey conducted in the study area, the depth to basement within the area was found to vary from a little less than 15m to a little greater than 25m. The depth to interface between the first and second layers varies from 0.15m in VES 7 to 1.77m in VES 18. The elemental composition of soil samples from the 22 VES investigation sites of Camp Area were analyzed using Atomic Absorption Spectrometer (AAS). Three main classes of elements were detected, these are: heavy metals, trace elements and major elements. The major elements include Calcium, Potassium, Phosphorus, Magnesium and Nitrogen; the trace elements are Manganese,

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